Subdivision 3Ps cod

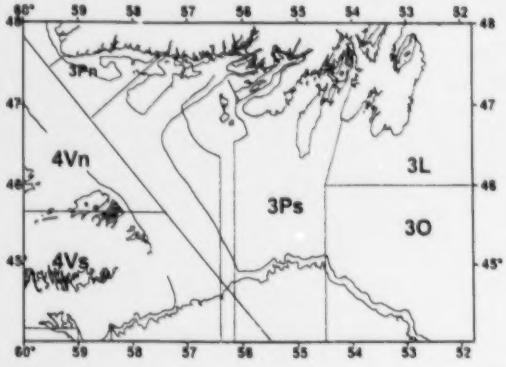
Background

In the Northwest Atlantic, cod are distributed from Greenland to Cape Hatteras and are managed as 12 stocks. The 3Ps stock off southern Newfoundland extends from Cape St. Mary's to just west of Burgeo Bank, and over St. Pierre Bank and most of Green Bank.

The distribution of 3Ps cod does not conform well to management boundaries and the stock is considered to be a complex mixture of sub-components. These may include fish that move seasonally between adjacent areas as well as fish that migrate seasonally between inshore and offshore. The extent to which the different components contribute to the fisheries is not fully understood.

Cod from this stock generally grow faster than those in more northerly areas. At least 50% of the females have been found to be mature by age 5 (53cm) in recent years, compared to age 6 (58cm) in the 1980s.

Catches from this stock have supported an inshore fixed gear fishery for centuries and have been of vital importance to the area. Fish are caught offshore by mobile and fixed gear and inshore by fixed gear. The stock was heavily exploited by Spain and other non-Canadian fleets in the 1960s and early 1970s. French catches increased in the offshore throughout the 1980s. A moratorium on fishing initiated in August, 1993 ended in 1997 with a quota set at 10,000 t. The TAC was subsequently increased to 20,000 t for 1998 and further to 30,000 t for 1999. Beginning in 2000 the management year was changed to begin on 1 April. An interim quota of 6,000 t was set for the first three months of 2000. The TAC for 1 April 2000 to 31 March 2001 was set at 20,000 t.



Summary

- The status of the 3Ps cod stock remains extremely difficult to assess because of variability in the research vessel survey index, incomplete reporting of all mortality caused by fishing, low fishing levels during the moratorium, and the mixing of fish between adjacent stocks. In particular, the extensive but variable mixing of 3Pn4RS and 3Ps cod in the Burgeo Bank/Hermitage Channel area during their over-wintering period creates difficulties for interpretation of catches and indices of stock abundance.

- Stock status was estimated from commercial landings in conjunction with abundance indices from Canadian (1972-2000) research vessel trawl surveys and sentinel surveys (1995-1999).

- An assessment based on all catches taken in 3Ps estimates that the spawning stock biomass was 82,000 t on 1 April 2000 and that it will decline to 76,000 t on 1 April 2001 if this year's TAC is taken; this is comparable to the spawning stock

biomass in 1992 just before the 1993 moratorium.

- Spawning stock biomass increased from 1993 to 1998 due to good growth, early maturation and good survival over the moratorium period by the 1989 and 1990 year-classes. This increase in spawner biomass was not sustained by subsequent recruitment, and spawning stock biomass has declined during 1998 and 1999.

- Spawner biomass on 1 Jan. 1999 is estimated at 106,000 t in this assessment compared to 147,000 t in the October 1999 assessment. This difference is a consequence of treating the survey data for the Burgeo Bank/Hermitage Channel area and the remainder of the stock area as two separate indices.

- This assessment estimates that spawner biomass peaked in 1998 and has subsequently declined, whereas the October 1999 assessment estimated that spawner biomass continued to grow until 1999. The difference is a consequence of data that became available since the October 1999 assessment.

- The downward trend in 3Ps spawner biomass in recent years was a consistent feature of all sequential population analysis (SPA) formulations considered in the current assessment.

- Estimates of abundance of the population aged three years and older show a general decreasing trend over the period 1959 to 2000.

- Estimates of year-class strength show a general downward trend over the period 1959 to 1999 with all year-classes from 1991-1996 being particularly low.
- There is a greater than 50% risk that spawner biomass will decline further in 2001-2002 at catch levels of 10,000 t or higher, and a greater than 89% risk at catch levels of 20,000 t or higher. The risk of exceeding 0.21 fishing mortality (the reference level used in the last assessment) with a catch of 10,000 t is 2% and with a catch of 20,000 t is 58%. The risk of exceeding 0.1 fishing mortality is 54% with a 10,000 t catch, and 99.6% with a 20,000 t catch. These risk analyses do not take into account uncertainties associated with the stock composition of the commercial catch.

- To explore the risks of transferring effort to the remainder of the stock due to seasonal closures, a second SPA was performed using information from only that part of the stock area east of Burgeo Bank/Hermitage Channel. To run the same 2% risk of exceeding the 0.21 fishing mortality reference level the catch option on this portion of the stock would be 5,000 t. The risk of exceeding 0.1 fishing mortality is 54% with a catch of 6,000 t.

- This document reports risk analyses for the whole of 3Ps and for the eastern portion alone. A risk analysis for the western portion cannot be obtained by simple subtraction, because the age-structures (and therefore relationship between catch and average fishing mortality) are different. The uncertainties are also different.

The Fishery

The stock was heavily exploited in the 1960s and early 1970s by non-Canadian fleets, mainly from Spain, with catches peaking at 84,000 t in 1961 (Fig. 1).

After the extension of jurisdiction in 1977, catches averaged around 30,000 t until the mid-1980s when fishing effort by France increased and total landings reached about 59,000 t in 1987. Catches then declined gradually to 36,000 t in 1992.

A moratorium was imposed in August 1993 after only 15,000 t had been landed. Although offshore landings have fluctuated, the inshore fixed gear fishery reported landings around 20,000 t each year up until the moratorium (Fig. 2).

The fishery reopened in May 1997 with a TAC of 10,000 t. This was subsequently increased to 20,000 t for 1998 and to 30,000 t for 1999. In 2000 the management year was changed to begin on 1 April. An interim quota of 6,000 t was set for the first three months of 2000. The TAC for 1 April 2000 to 31 March 2001 was set at 20,000 t.

Landings (000s t)

Year	77-92 Avg.	1993	1994	1995	1996[1]	1997[1]	1998	1999	2000[1] (J-M)	2000-2001[1]
TAC	-	20	0	0	0	10	20.0	30.0	6.0[2]	20.0
Can.	29	15	1	1	1	7	16.5	24.9	3.5	5.4
Other	12	+	-	-	-	2	3.1	3.2	2.5[3]	3.1
Totals	41	15	1	1	1	9	19.6	28.1	6.0	8.5[4]

[1] Provisional.

[2] During 2000 the management year was changed to begin on 1 April (rather than 1 January) and an interim TAC of 6,000 t was allocated for the first three months (Jan.-Mar.) of 2000

[3] France is allocated 15.4% of the TAC but carried forward a portion their 1999 allocation to the first three months (Jan-Mar) of 2000.

[4]Approximate landings to end of September 2000.

In 1999 reported landings were 28,100 t, mostly from the inshore fixed gear sector. This included a French catch of about 3,200 t of which approximately 2,500 t was caught by otter trawlers and the remainder by fixed gear, particularly gillnets.

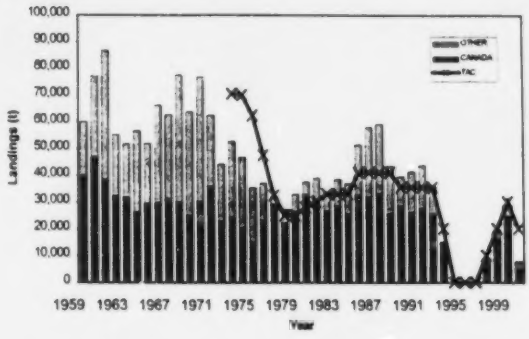


Figure 1. Reported landings (t) by country.

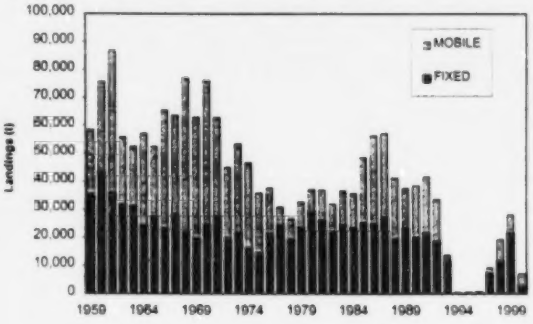


Figure 2. Reported landings (t) by gear sector.

The **age composition** of the fixed gear catch from 1999 comprised a range of ages from 3 to 15 with most of the catch comprised of 5-10 yr olds and age 7 (1992 year class) predominating. Otter trawl catches in the offshore commercial fishery, also consisted mostly of 5-10 yr olds but with ages 5-7 and 9-10 predominating.

The catch in the first three months of 2000 consisted mostly of 6-11 yr olds but with ages 7-8 and 10-11 predominating.

Species biology

Stock structure and **migration patterns** of 3Ps cod are complex and poorly understood. Migration of offshore components of the stock to inshore areas during spring and summer, as well as the existence of inshore components that remain outside the survey areas throughout the year, also complicate the assessment of stock status.

Mixing of northern Gulf (3Pn4RS) cod with 3Ps cod in the Burgeo Bank-Hermitage Channel area of 3Ps during winter continues to present problems. The offshore portion of this area (3Psd) was closed to directed cod fishing from 15 Nov. to 15 Apr. in 1998-1999 and 1999-2000; significant landings from this area during this time period could have detrimental effects on the recovery of the neighbouring 3Pn4RS cod stock.

Tagging studies initiated in 1997 in Placentia Bay were expanded during 1998-2000 to include Fortune Bay and two offshore areas (Burgeo/Hermitage Channel and Halibut Channel). In these four years over 31,000 fish have been tagged. Returns indicated that offshore stock components contributed to inshore fixed gear catches on the south coast during the summer in both 1998 and 1999. Cod tagged in the Burgeo/Hermitage Channel area in April 1998 showed a similar distribution of recaptures in both 1998 and 1999; a high proportion moved into 3Pn-4RS and others migrated north and eastward along the inshore of 3Ps. However, tagging in the Burgeo/Hermitage Channel area in April 1999 gave recaptures mostly within 3Ps during the 1999 fishery.

Recaptures also indicated a spring-summer movement of cod from the inner reaches of Placentia Bay toward the mouth of the bay. Several of these cod were recaptured in 3L during the 1998 index fishery and the 1999 commercial fishery. The pattern of recaptures suggests a movement of some 3Ps cod across the stock management boundary into 3L during late spring, with a return migration during late fall. Historical and recent tagging of cod offshore in southern 3Ps also revealed some movement of cod between this area and the southern Grand Banks (3NO).

Proportion mature at age in female cod sampled during research trawl surveys has increased among younger cod, particularly since the late 1980s (Fig. 3). For example, the proportion of 6 yr old females that are mature has increased from about 30% in the 1970s and early 1980s to over 80% in recent years.

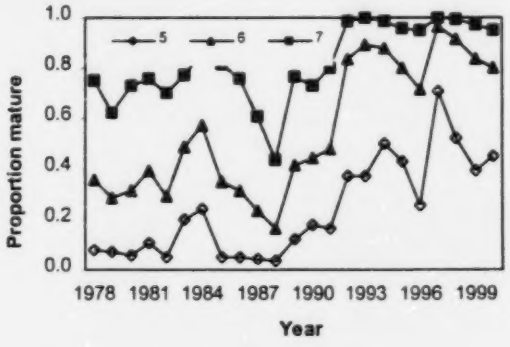


Figure 3. Estimated proportion mature at ages 5-7 (females).

Males generally mature about one year younger than females but show a similar trend over time.

Spawning is spatially widespread in 3Ps, occurring close to shore as well as on Burgeo Bank, St. Pierre Bank, and in Halibut Channel. Timing of spawning is variable and extremely protracted, with spawning fish

present from March until August in Placentia Bay. The proportions of fish at various stages of maturation seen during the 2000 spring research vessel survey were similar to those seen in recent years.

Growth, calculated from length-at-age in research trawl survey samples, has varied over time. For the period 1972-2000, peak lengths-at-age occurred in the mid-1970s for young ages and progressively later for older ages (Fig. 4). From the mid-1980s to the late 1990s, length at age varied with no trend (younger ages) or declined (older ages).

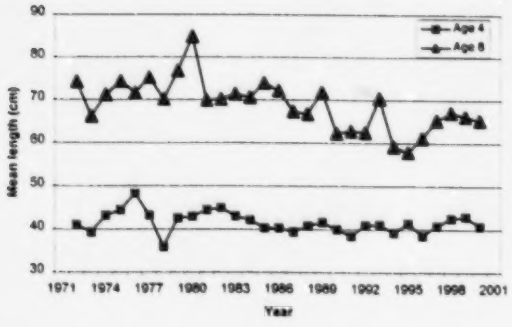


Figure 4. Mean lengths (cm) at age from RV survey.

The **condition** of cod is typically expressed as W/L^3, where W is either the gutted weight of the fish or the liver weight, and L is the length. Condition varies seasonally and tends to decline during winter and early spring.

Cod collected during the April 2000 research vessel survey were generally in better condition than those sampled at the same time of year during 1993-95; comparison of post-1992 condition with that observed during 1985-1992 is difficult because survey timing has changed. Nonetheless, condition of cod in the 1995-2000 surveys appeared to be normal.

Industry perspective

A perspective on several aspects of the 1999 commercial fishery is available from the responses to a questionnaire sent by the Fish, Food and Allied Workers (FFAW) Union to the fish harvesters' committees in 49 communities. Twenty six of the committees responded to the questionnaire.

In response to whether commercial catch rates in 1999 were low, average, or high, 50% said high, 38% said average, and 12% said low. When 1999 was compared to 1998, 40% said higher, 44% said the same and 16% said lower. Catch rates were perceived to be low on the western side of Placentia Bay, but average to high elsewhere.

Collection of information on the 2000 fishing season was incomplete.

Resource Status

Sources of information

Stock status was estimated from **commercial landings** in conjunction with **abundance indices** from Canadian (1972-2000) research vessel trawl surveys and sentinel surveys (1995-1999).

Information from research vessel surveys

Canadian research vessel bottom **trawl surveys** were conducted from 1972-1982 by the research vessel A. T. Cameron using a Yankee 41.5 otter trawl. Surveys from 1983 to 1995 were conducted by the Wilfred Templeman, or the sister ship the Alfred Needler, using the Engel 145 Hi-Lift otter trawl. Since 1996 the survey has been

conducted by the Wilfred Templeman using the Campelen 1800 shrimp trawl. Data collected with the gear used in 1983-1995 were converted to Campelen equivalents. Survey results from the Burgeo Bank/Hermitage Channel area and elsewhere in 3Ps are presented separately to be consistent with the current analyses.

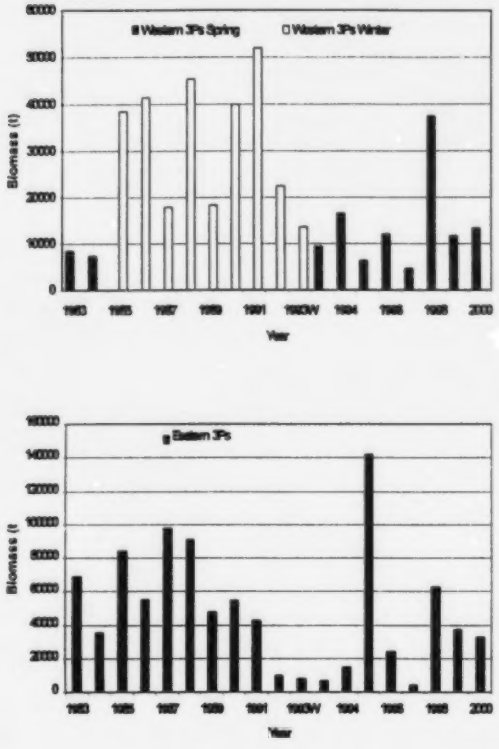


Figure 5. 3Ps survey biomass index (t).

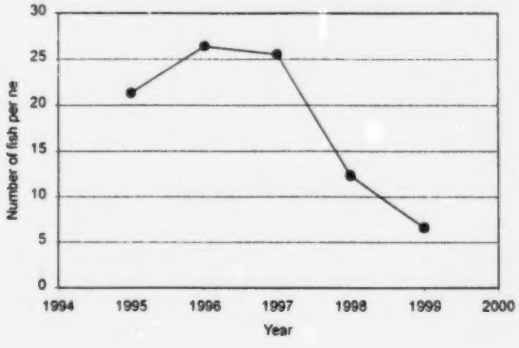
The survey **biomass index** from each area shows a declining trend from the mid-1980s to the early 1990s but is variable, particularly during the past 5 years (Fig. 5). The biomass index in 2000 for both areas combined was 46,000 t, approximately the same as in 1999. The most numerous ages in the Burgeo Bank/Hermitage Channel portion were 4-7 and elsewhere 2-4. No particularly strong year classes were present anywhere. Survey catches over the past three years have consistently shown few survivors from year classes prior to 1989.

Sentinel survey

A fixed gear **sentinel survey** has been conducted at several sites along the south coast of Newfoundland from St. Brides to Burgeo. The survey began in late February of 1995 and continued in 2000 but there was insufficient sentinel activity in the first half of 2000 to extend the analyses to include the current year.

Gillnet catch rates, mostly from sites in Placentia Bay, show strong seasonality and are consistently highest during fall in the eastern side of Placentia Bay. Line-trawl catch rates, mostly from sites west of the Burin Peninsula exhibit strong seasonality within each year.

Sentinel survey catch rates for gillnets and line-trawls were standardized to account for site and seasonal effects to produce annual indices of total catch rate and catch rate at age for each gear.



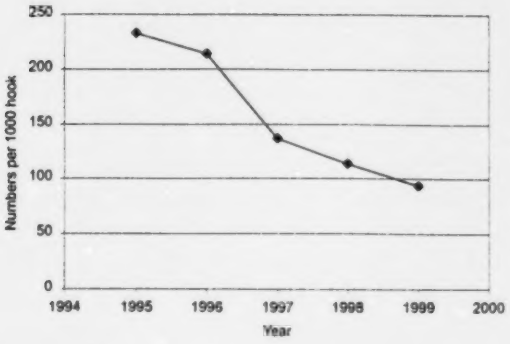


Figure 6. Standardized sentinel catch rates for gill nets (upper panel) and line-trawls (lower panel).

The **standardized total annual catch rates** for gillnets show no clear trend during 1995-1997, but were much lower in 1998 and 1999 (Fig. 6, upper panel). Line-trawls show a consistent declining trend since 1995 (Fig. 6, lower panel).

Science log-books

Inshore catch rate data from science log-books for vessels <35 ft for the period 1997 to 1999 suggest a seasonal cycle in gillnet catch rates within each year with an overall declining trend between years in 3Psa and 3Psb, but no trend in 3Psc. Line-trawl catch rates also show some seasonality, with a declining trend between years in 3Psa, no trend in 3Psb and insufficient data in 3Psc.

Other considerations

Temperature

The warming trend seen in 1998 and 1999 has continued, with complete disappearance of subzero °C water and an increase in the extent of relatively warm (>1°C) water on St. Pierre Bank in 2000.

Cold water in the lat 1980s and early 1990s was associated with a disappearance of cod from the shallow strata on top of St. Pierre Bank and a shift to deeper water at the time of year when the research trawl survey was conducted. Survey results from the most recent years when waters are warmer suggest some reappearance of cod in these shallow strata.

Population Analysis

In the commercial catches we are unable to reliably distinguish between 3Ps cod and those from adjacent stocks. The nominal reported catches of cod from 3Ps were used in the SPA for an assessment of the stock. This does not address the issue of mixing. However, it is thought that the region east of the Burgeo Bank/Hermitage Channel area contains only 3Ps cod. We therefore also report an analysis restricted to that region for which mixing is less of a problem.

The first **sequential population analysis** (SPA) was based on the total reported commercial catch, information from the Templeman survey (1983-2000), the Cameron survey (1972-1982), and the sentinel gill net and line-trawl surveys (1995-1999).

In the 1999 assessment, the issue of stock mixing at the time of the survey was addressed by removing Burgeo strata from the winter portion of the survey time series (1983-1992). The Burgeo strata were included as part of the spring series (1993-1999). In the present assessment it was considered more logical to split the Templeman index into two: one for April surveys in the Burgeo Bank/Hermitage Channel area and one for the remaining 3Ps area (winter and spring series combined). For

the Burgeo Bank/Hermitage Channel index only April surveys in the recent years (1993-2000) were used in the SPA. The Cameron survey index was also based only on the area of 3Ps excluding the potential mixing area because many of these surveys were conducted during winter.

The SPA estimates the accuracy of each index and hence the weight it should be given in the final result. The SPA gives the Templeman survey index for the Burgeo Bank/Hermitage Channel area lower weight, as would be expected if this is a poorer index of 3Ps stock abundance. This is consistent with the observation that cod tagged in April in the Burgeo Bank/Hermitage Channel area in 1998 were recaptured in the Gulf, whereas in 1999 they were recaptured mostly in 3Ps.

Population biomass and spawner biomass declined from high values during the late 1950s to the mid-1970s, then increased to a peak in 1985 (Fig. 7). The stock declined from the mid-1980s to the early 1990s, but increased rapidly during 1993-1997 following the moratorium. Population biomass and spawner biomass are estimated to have decreased during 1998 and 1999. The current (1 Jan. 2000) **population biomass** is estimated to be 123,000 t. and **spawner biomass** is estimated to be 92,000 t.

Spawner biomass on 1 Jan. 1999 is estimated at 106,000 t in this assessment compared to 147,000 t in the October 1999 assessment. This difference is a consequence of treating the survey data for the Burgeo Bank/Hermitage Channel area and the remainder of the stock area as two separate indices.

The current assessment estimates that spawner biomass peaked in 1998 and has subsequently declined, whereas the October 1999 assessment estimated that spawner biomass continued to grow until 1999. The difference is a consequence of data that became available since the October 1999 assessment.

The downward trend in 3Ps spawner biomass in recent years was a consistent feature of all SPA formulations considered in the current assessment.

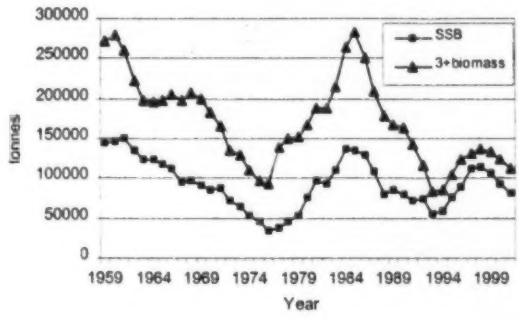


Figure 7. Spawner biomass and 3+ biomass.

Recruitment estimated from the SPA has been variable in 3Ps, but shows a long-term decline (Fig. 8). Recruitment during the mid- to late-1990s does not appear to be strong, but has increased somewhat in 1999-2000. Note that the recent estimates of recruitment have more uncertainty than the historic estimates.

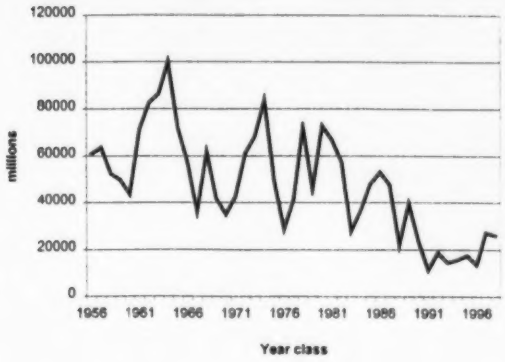


Figure 8. Recruitment (numbers at age 3).

Annual **exploitation rates,** expressed as % of numbers removed by the fishery, varied over time. Exploitation increased from the late 1950's to a peak of over 24% in 1975 and declined to a low of approximately 10% in 1984 then increased rapidly to between 18 and 25% just prior to the moratorium in 1993 (Fig. 9). With the reopening of the fishery in 1997, exploitation rates were low in 1997 relative to the pre-moratorium period but increased to 13.7% in 1999, the last completed year of the fishery.

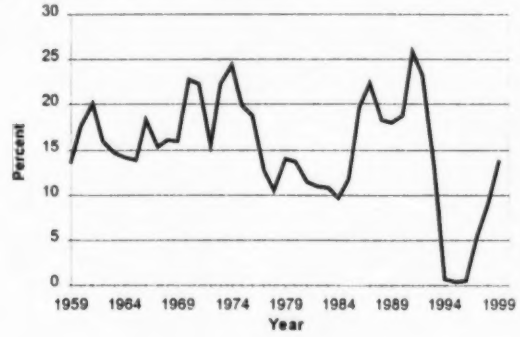


Figure 9. Exploitation rate.

If fishery closures in western 3Ps lead to a transfer of effort to the remaining areas of 3Ps, then the exploitation risks for the remaining part of the 3Ps cod stock could change, particularly if there is limited mixing between fish from the closed and open areas.

To illustrate the risks of transferring effort to the remainder of the stock, an SPA was performed using information from only that part of the stock area east of Burgeo Bank/Hermitage Channel (i.e. excluding 3Psa and 3Psd). It was conducted using the reported commercial catches outside the mixing region for the entire year, the Templeman survey index excluding the Burgeo Bank/Hermitage Channel area, the Cameron survey index, and the sentinel gill net index. The sentinel line-trawl index was excluded because the results typically came from the western portion of the stock area.

Population biomass and spawner biomass estimates show similar trends to those from the entire 3Ps region, but fish in this eastern portion are, at present, younger on average. The 1 Jan. 2000 **population biomass** for this eastern portion is estimated to be 93,000 t. and **spawner biomass** is estimated to be 68,000 t.

Risk analyses

A risk analysis based on the SPA for the entire 3Ps region was used to propagate the uncertainty in the estimated population size to 1 April 2002. The uncertainties reflect only the discrepancies between the surveys and the SPA; they do not include uncertainties about mixing. The risk of the spawning stock not growing and the risk of exceeding 0.1 and 0.21 fishing mortality (average for ages 7-14) were considered for a range of catch options. The reference point of 0.21 fishing mortality was the level estimated as $F_{0.1}$ in the last assessment of this stock, and 0.1 fishing mortality is commonly thought to be a safe level of exploitation.

The risk of exceeding 0.21 fishing mortality in the management year 1 Apr. 2001 to 31 Mar. 2002 with a catch of 10,000 t is 2% and

with a catch of 20,000 t is 58% (Fig. 10). The risk of exceeding 0.1 fishing mortality is 54% with a 10,000 t catch, and 99.6% with a 20,000 t catch.

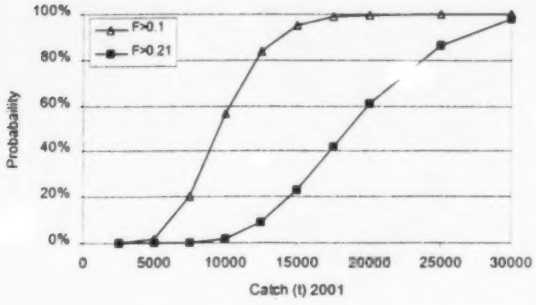


Figure 10. Risk of exceeding 0.1 and 0.21 fishing mortality.

The risk of spawning stock biomass declining at the end of the management year for a 10,000 t catch is 50%, and at a 20,000 t catch the risk is 89% (Fig. 11). At 20,000 t the risk of spawning stock biomass declining below the lowest level between 1959-2000 is 2.7%.

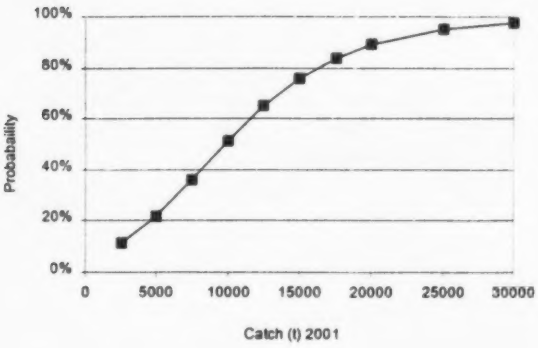


Figure 11. Risk of spawning stock biomass declining.

A second risk analysis was conducted using the SPA for the part of the stock excluding the mixing region. To run the same 2% risk of exceeding the 0.21 fishing mortality reference level the catch option on this portion of the stock would be 5,000 t. The risk of exceeding 0.1 fishing mortality is 54% with a 6,000 t catch (Fig. 12). A catch of 12,000 t would result in the same 50% risk of spawning stock biomass declining at the end of the management year (Fig. 13).

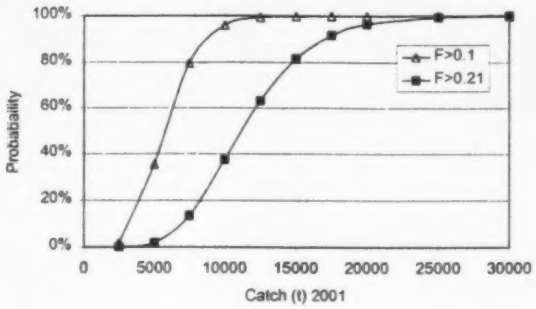


Figure 12. Risk of exceeding 0.1 and 0.21 fishing mortality for the eastern 3Ps area.

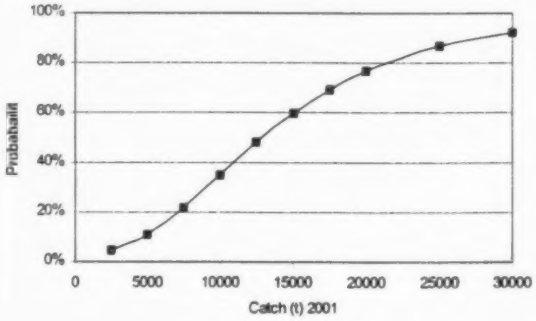


Figure 13. Risk of spawning stock biomass declining for the eastern 3Ps area.

Sources of uncertainty

The status of the 3Ps cod stock remains extremely difficult to assess because of variability (e. g. year effects) in the research vessel survey index, incomplete reporting of all mortality caused by fishing, low fishing levels during the moratorium, and the mixing of fish between adjacent stocks.

Uncertainty in the interpretation of the survey index is aggravated by past changes in the timing of the survey. In the previous assessment, strata in the western portion of the survey area (Burgeo Bank) were removed from the February-March survey index to reduce the problem of northern Gulf cod mixing into 3Ps. In the present assessment the Burgeo/Hermitage Channel portion of the survey was treated as a separate index due to possible mixing extending into April.

To estimate population numbers it is necessary to make assumptions about how commercial fishery selectivity changes with size and hence age. Different assumptions about how this selectivity changes, as well as different treatments of the survey data, can produce estimates that are half or double those produced by the form of the model used in the risk analyses. A particular concern is that the model estimates that larger, older fish are caught in a much lower proportion relative to their abundance than younger fish and this is not easy to explain. If older fish are selected more strongly than is estimated in the current assessment then spawner biomass is overestimated and the risk associated with the catch options considered will be underestimated.

In addition to uncertainties related to model formulation and input data, there is considerable uncertainty regarding the origins of fish found in 3Ps at various times of year. Tagging experiments suggest that the amount of mixing with adjacent stocks can vary from year to year. The assessment is sensitive to mortality on 3Ps cod occurring when fish are outside 3Ps and to the incursions of non-3Ps fish into the stock area at the time of the survey and the fishery.

The risk analyses, although more comprehensive than those conducted in the past, reflect only the discrepancies between the survey indices and the particular form of the model used in the SPA, and not for example uncertainties associated with stock mixing, misreported catches and assumptions about natural mortality.

Outlook

An assessment based on all catches taken in 3Ps estimates that the spawning stock biomass was 82,000 on 1 April 2000 and that it will decline to 76,000 on 1 April 2001 if this year's catch is taken; this is comparable to spawning stock biomass in 1992 just before the 1993 moratorium.

Spawning stock biomass increased from 1993 to 1998 due to good growth, early maturation and good survival over the moratorium period by the 1989 and 1990 year-classes. This increase in spawner biomass was not sustained by recent recruitment and spawning stock biomass has declined since 1998. Estimates of year-class strength show a general downward trend over the period 1959 to 1999 with all year-classes from 1991-1996 being particularly low.

There is a greater than 50% risk that spawner biomass will decline further in 2001-2002 at catch levels of 10,000 t or higher. The risk of exceeding 0.21 fishing mortality (the reference level used in the last assessment) with a catch of 10,000 t is 2% and with a catch of 20,000 t is 58%. The risk of exceeding 0.1 fishing mortality is 54% with a 10,000 t catch, and 99.6% with a 20,000 t catch. These risk analyses do not take into account uncertainties associated with the stock composition of the commercial catch.

To explore the risks of transferring effort to the remainder of the stock due to seasonal closures, a second SPA was performed using information from only that part of the stock area east of Burgeo Bank/Hermitage Channel. To run the same 2% risk of exceeding the 0.21 fishing mortality reference level the catch option on this portion of the stock would be 5,000 t. The risk of exceeding 0.1 fishing mortality is 54% with a catch of 6,000 t.

This document reports risk analyses for the whole of 3Ps and for the eastern portion alone. A risk analysis for the western portion cannot be obtained by simple subtraction, because the age-structures (and therefore relationship between catch and average fishing mortality) are different. The uncertainties are also different.

Management Considerations

Mixing between 3Pn4RS and 3Ps stocks during the over-wintering period impacts both the assessments and management of these stocks. A fishery closure as in the past two fishing seasons is but one of several options for addressing conservation concerns. It is recommended that an iterative consultation process between scientists, fisheries managers and the industry be developed jointly for both stocks. In such a process, management measures could be suggested and the impact of these relative to the mixing issue could be assessed.

The incentive for under-reporting of catches has increased with the implementation of trip limits, IQ's, and quality-based price differentials. Increased monitoring of catches and landings would result in better estimates of deaths caused by fishing.

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